ENGINEERING-EDUCATION

Bulletin of the
Society for the Promotion of Engineering Education

Vol. VIII LANCASTER, PA., MAY, 1918 No. 9

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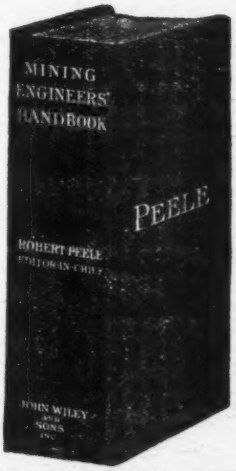

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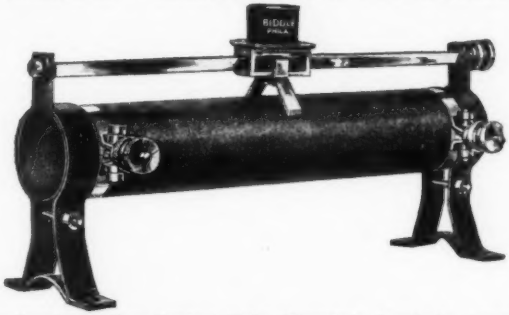

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BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

Milo S. Ketchum, G. R. Chatburn, F. L. Bishop, *Editor.*

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. VIII LANCASTER, PA., MAY, 1918 No. 9

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A MOVEMENT FOR GREATER RECOGNITION OF SCHOLARSHIP.

Report of a Committee of the Cornell University Faculty on the Alumni Inquiry Regarding the Recognition of Scholarship.

The question which this committee was instructed to consider was first raised by the board of directors of the Associate Alumni, when, on March 31, 1916, it voted to offer to the faculty the assistance of its organization in securing recognition for unusual excellence in scholarship on the part of students of the university and asked the faculty to suggest means whereby such recognition could be made most effective. This committee was appointed by the faculty to consider the question thus raised and to recommend such action as might form a suitable response to the inquiry from the alumni.

A. Suggestions for Action by the Faculty.

1. The committee recommends that an annual convocation of the members of the university be devoted, at least in part, to the recognition of academic honors. Such an assembly was first suggested by Mr. Hoy. At present, academic honors are officially noted only on the commencement programme, for the benefit of the graduating class and its friends. Athletic distinctions, on the contrary, are awarded with impressive ceremony, before a representative student gathering. The committee believes that we owe it to the recipients of academic honors to give formal recognition to their achievements. At the convocation proposed an address might well be given by a distinguished speaker, who, if possible, should be an alumnus of this university. The committee originally contemplated, as an appropriate date for such an assembly, the day of the meeting of the board of trustees in April; but two objections to this

arrangement have been offered: (*a*) the trustees already have rather a busy day, and (*b*), as Professor Keniston suggests, it would be too late in the year, if the occasion is to impress the students and especially the freshmen with a realizing sense of the opportunities of which they may and should take immediate advantage. At Harvard the "Award of Academic Distinctions" is held early in the year and is said to have had an excellent influence on new students. Possibly this precedent might be followed, or, as the committee is now prepared to recommend, the proposed recognition of academic honors could be given on Founder's Day. This might be sufficiently early, there would be more time for the speaker of the day, and the honor which we owe to the memory of the founder of the university would be appropriately combined with the recognition of those who had proved their right to profit by his devotion and by the generosity of their other benefactors.

2. The committee recommends that the faculty give recognition, at such an occasion as has just been suggested or in some other manner, to those students who are honored by election to Phi Beta Kappa, to Sigma Xi, to Tau Beta Pi, or to any similar society.

3. The committee recommends that the faculty request its special committee on prizes to consider and report upon means whereby those prizes which appear to be commonly neglected may be made more effective incentives to intellectual effort.

4. The committee recommends that the university faculty recommend to the several college faculties the institution, if possible, in each college, of an "orientation course" for freshmen. Such a course might cover such topics as these: the nature of a university; the history, organization and characteristics of Cornell University; your college and its work; the work of the other colleges; the University Library; undergraduate life; how to study and how to make the most of your mental apparatus and of your academic opportunities; how to improve your physical condition; how some great men were educated; some scientific and social problems that await solution; the

choice of your vocation. Orientation courses of this general character are now given at several colleges and universities and appear to have proved their value. With us the freshman is "orientated" by upperclassmen, by the athletic authorities, and at "get-wise" meetings in some of the colleges and at Barnes Hall. The committee is indebted to Professor Burr for a copy of the syllabus for the orientation course at Brown University, which will be submitted to the inspection of the faculty.* The committee hopes that, if similar courses are undertaken here, they will not consist merely of lectures, but that an effort will be made to elicit ideas from the freshmen themselves.

5. The committee transmits to the faculty for transmission to the several college faculties the suggestion that in each college honorary undergraduate scholarships, without stipend, be annually awarded on the basis of scholastic rank.

6. The committee transmits to the faculty for transmission to the several college faculties a proposal to recognize honor groups, consisting of the best students in each class in each college, whose names could be published in the University Bulletin and announced at the proposed convocation on Founder's Day.

Further than these recommendations, so far as formal action by the faculty is concerned, the committee is not at present prepared to go; but certain other suggestions and opinions have been laid before it which seem worthy of consideration on the part of members of the faculty.

We have received from Mr. George H. Ashley, of the class of 1889, in a letter appended to this report, the suggestion that, in addition to credits for quantity, secured by attaining pass-

* The rules for the course at Brown and a list of lectures for the current year are printed at page 28 of this report. The course is described by Professor W. H. Kenerson in the BULLETIN OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, Vol. VI (1916), pp. 423 ff. A similar course at Reed College is described in the *New York Times* of April 15, 1917.

ing grades, additional credits for quality be required of all students.

We have received from Professor Davenport a communication also appended to this report, outlining a new plan for the standardization of marks.

Professor English suggests that a student who has been put on probation should not be allowed to take part in extra-curricular activities until he has completed, after the expiration of his period of probation, an entire term in good standing.

Professor Keniston suggests a system of "degrees with distinction," to be recognized on the commencement programme and on the diplomas of those students to whom such degrees are granted. Professor Karapetoff makes a similar recommendation.

Several of our correspondents have suggested action to be taken with reference to fraternities: that no fraternity should be allowed to admit a freshman until after he has spent one term at the university; that no student be admitted who is on probation or who has not received marks of a certain grade; that fraternities whose records are poor be subjected to certain restrictions; that every fraternity be required to have two alumni members living in the house. Professor Kimball says that he has "always been much impressed with the lack of interest shown by members of our own faculty in the affairs of their own fraternities," and believes that "most of the evils of the campus could be reformed quickly if every member of the university faculty would try to do what really is his duty in connection with the group of students with which he is thrown in most intimate contact."

Several members of the faculty and several of the students whose letters are included in the appendix have recommended the institution of "courses for honors," to which those students would be admitted who had shown marked ability and upon admission to which they would be relieved of certain requirements and entitled to certain privileges. This suggestion was offered originally by a group of seniors in the college of

arts and sciences and has now been approved by the faculty of that college; but it may be that the idea also deserves attention in other colleges in the university.

It will be noted that several of our student correspondents put the responsibility for the undergraduate attitude toward scholarship squarely up to the faculty; and also that Dean Thilly, in a hitherto unpublished extract from his report to the president for last year, urges the members of the faculty to set their own house in order.

The committee has observed numerous indications of a widespread conviction that the faculty should take more effectual action for the exclusion of those students whose ability or whose ambition does not justify their membership in the university. It is generally recognized that the presence of these "non-conductors" lowers the tone of the whole body and that they are present in considerable numbers; but however directly this situation bears upon the problem of student scholarship, the committee has not felt warranted in attempting to discuss it.* Each of the college faculties now has full power to excuse from further attendance students who might better be spending their time elsewhere. The question of a change in our method of admitting students has been referred by the university faculty to another committee. We venture, however, to call attention to the circumstance that at Reed College no candidate is ordinarily admitted who has not ranked in the first third of his class at school. It is clear that a distinction of this kind, might be applied to students entering by examination or on regents' certificates as well as to those who present school certificates, and that admission to the university might thus be put on a competitive basis. The *Alumni News*

* Four significant contributions to the discussion of the question have appeared in the *Alumni News:* Professor Davenport's address on "The Depreciating Dollar and University Policy," in the number for February 1; Dr. van Loon's article, "No Compromise!" in that for March 1; Professor Willcox's letter to the committee (see p. 22) in that for March 8; and Professor Keniston's article on entrance methods in that for March 22.

(February 15, 1917) assures the faculty that the alumni will not complain if a maintenance of real university standards shall cause a reduction in the size of the university; and Mr. R. W. Sailor writes to the committee: "To produce real scholars from the undergraduate body, it is necessary, it seems to me, to have a faculty composed of scholars and to weed out the delinquent students to as great a degree as is necessary to give a scholarly faculty sufficient time, by freeing them from unnecessary work in trying to educate uneducatable students, so that the faculty composed of scholars can impress its scholarship on the remaining students."

The committee has also found evidence of a general impression that, under existing conditions, an excessively large amount of instruction is given by inexperienced and inexpert teachers.* It is apparent that this is a matter which is forcing itself upon the consideration of university authorities elsewhere. A Cornell alumnus, Professor J. A. Leighton, of The Ohio State University, in an article on "Democracy and Intellectual Distinction" in *School and Society* for April 14, 1917, alleges that college and university chairs in America are being manned largely by mediocre men and that the increase in the number of students is commonly met "by hiring cheap and untried instructors to teach an ever-multiplying and bewildering variety of courses." As for Cornell, the committee has heard of one freshman who informed his father that most of his teachers during the year had not seemed really interested in their subjects and, on the other hand, of another student, who, after a year at another university, came back to Cornell, because there he would be taught only by young instructors, while here he would be taught by professors. With reference to this very serious problem, an interesting suggestion has been offered to

* The direct relation between the recent increase in the number of students and the decreased proportion of professors and assistant professors to the whole number of teachers is brought out very clearly in a table published in the *Alumni News* for March 8, 1917. "Some way," says the *Alumni News* (p. 258), "must be found to check the University's horizontal growth until it has become able to build itself up."

the committee by Mr. Sidney P. Howell, a member of the present senior class, himself an assistant in history. "I believe," says Mr. Howell, "that professors ought to spend more time with the freshmen than with any other class save perhaps the seniors. How can you expect these poor lads who have no idea how to work to accomplish anything under instructors and student assistants whose knowledge after all isn't much greater than that of the freshmen? How can you improve your scholarship if you have no foundation upon which to build? Even now, the freshman year safely past, the sophomores and juniors know how to attack, but the lack of proper experience handicaps them throughout their course, and they attack less effectively, on the whole, than they might. Given the proper supervision while learning the new process, less experienced teachers might easily guide them through the middle years with as great success as the best, because, the process once learned, it is up to the student rather than to the teacher to produce results."

While it is probable that members of the faculty have commonly regarded the problem thus indicated as insoluble except through a large increase in the endowment of the university, for which they must look to the trustees and the alumni, it is the opinion of Mr. Newman that the initiative for any considerable improvement must come from the president and the faculty. Similarly a member of the faculty, Professor Cooper, suggests the appointment of a committee to consider the best methods of securing new members of the teaching force. "Far too many classes," says Professor Cooper, "are like cadavers undergoing dissection at the hands of neophyte surgeons."

The committee feels considerable sympathy with the younger members of our teaching staff at whom so much unfavorable criticism has been levelled. They have been encouraged to undertake work to which they have been told that they were equal. In the criticism to which they have been subjected they may at least find an incentive to show what they can do. Per-

haps they have a right to expect more guidance than they now often receive. Perhaps more adequate provision should be made for their training as teachers. When, however, the committee in its request for advice suggested "lectures on methods of teaching" for members of the instructing staff, the proposal elicited an unfavorable reaction from almost all the professors from whom the committee has heard. In this form the suggestion appears to have been unpalatable. Surely, however, most members of the faculty continually subject themselves as teachers to self-criticism and do their best to profit, as teachers, by their own and by others' educational experience. Surely teaching is an art that has, like other arts, a foundation in theory. Surely, neophyte teachers as well as neophyte surgeons may be helped by instruction from those who have more completely mastered this difficult art. The committee has no thought of depreciating the importance of productive scholarship as a prerequisite for successful teaching in a university. We agree with Professor Cooper when he maintains that in the long run the best scholars are the best teachers. We agree with Mr. Hoy when he says: "What an instructor who does not know his subject would get out of lectures on teaching is beyond me." Whether Mr. L. V. Heilbrunn, of the class of 1911, is correct in thinking that what we most need is more inspiring teaching, or whether a member of the class of 1915 is justified in his criticisms of the faculty published in the *Alumni News* for April 12 and included in the appendix of this report, the committee will not attempt to say; but it is prepared to express the hope that we who are so prone to criticize others will not refuse to entertain criticism of ourselves. The committee will not go so far as to indorse the opinion of Mr. R. W. Livingstone, of Corpus Christi College, Oxford,* that "no one should teach who has not studied the theory of teaching"; nor will it recommend the institution of such a series of talks to instructors as has been given at the Iowa State

* In his latest work, "A Defence of Classical Education," p. 270. The whole passage is quoted at p. 43 below.

College on "Teaching How to Study," "The Laws of Memory," "The Conduct of Recitations," "Good Questioning" and similar subjects; nor will it advise any department to follow the precedent set by the department of economics at Harvard when it invited the sister department of education to investigate the undergraduate instruction in economics with a view to its improvement;* nor will it recommend that any of our colleges imitate the procedure of the Massachusetts Institute of Technology in appointing a faculty committee on methods of instruction, under a chairman who will devote his entire time to the work for three years, with special reference to the problem of preventing an overcrowded curriculum and to that of securing the proper training of instructors.† The committee will go no further than to call attention to these facts and also to an article by one of its members, Professor Jacoby, on "Some Details in Engineering Education" (in the Proceedings of the Society for the Promotion of Engineering Education, Vol. 24, 1916) in which certain pedagogical questions with which all university teachers have to deal are discussed and reasons are given for the belief that, under existing conditions, it is desirable for a technical college or the university of which it forms a part, to make an organized effort to improve the teaching power of its instructors.

One specific improvement in our practise is recommended to the committee and to the faculty by professors who believe that too much of our instruction is given in the form of lectures. They agree with Socrates. "The lecture system," says Professor Willcox, "under-values the class as a social group and the educational stimulus and value of the interactions between its members." "There is too little self-activity," says Professor Cooper "on the part of the student, who does not like to be passive (though he is willing to be entertained) and naturally turns to the 'student activities,' in order to find something to do that he deems worthy of a man with a back-

* See President Lowell's report for 1915–16.

† Cf. *The Engineering News-Record*, April 5, 1917, p. 58.

bone." "The interest of students," says Professor Winans, "would be much quickened, if each department would turn its attention to working methods by which the student could more often experience the joy of accomplishment, and could bring that accomplishment before his fellows, to be fought over perhaps, and not merely submit it to an instructor." "Every difficult problem in mechanics or in electricity," says Professor Karapetoff "should be a community problem for the class, and not an individual problem for Mr. Jones."

It seems to the committee that, so far as individual or corporate action by members of the faculty is concerned, no better formulation of its general conclusions could be found than the words in which a member of the senior class, Mr. Bertram F. Willcox, sums up the whole matter: "If college work could be made competitive and interesting and social, surely the students would respond by making it honorable."

B. Suggestions for Action by the Alumni.

Addressing itself now to the alumni, upon whose initiative this whole inquiry has been undertaken, the committee would be glad, if it could, to give adequate expression to the gratification with which the faculty welcomes the expression of their concern for the higher interests of the university. We believe that their devotion to their alma mater and their gratitude to her founders and benefactors, to the national government, and to the state, could take no more substantial or impressive form than this. We believe that the alumni have an opportunity, the significance of which we are only just beginning to realize, to aid in effecting that change in the mental attitude of many of our undergraduate students, in which we recognize the necessary condition for the real vitality and the true success of the university. Such a change will not come over night; the influence of the alumni must be exerted during a long series of years and for generations to come.

The university, as we all know, cannot do its work without the financial assistance of its alumni, to whose loyalty and

liberality it owes indispensable and increasing additions to its resources. An alumni fund amounting to $100,000 a year, the immediate goal of the Cornellian Council, would be equivalent to the income from an endowment of about two millions. Other universities are receiving additions to their productive funds on a similar or a larger scale. Some state universities in the West and some of the older endowed universities of the East are forging ahead more rapidly than we are. If Cornell it to live up to its traditions and to meet its opportunities, if it is to maintain a large faculty of real scholars and real teachers, if its library is to hold its place secure among the great libraries of the country, if it is to be adequately equipped with buildings and educational appliances, if it is to continue to be a first-rate, a many-sided and a large university and not to become a second-rate, a lop-sided or a much smaller university that at present, it must have all the money than its alumni can give or induce others to give; but this is not the only thing nor possibly the most important thing that they can do for Cornell. Size or prominence is not essential to the greatness of a university. We can still be a first-rate univesity on a modest and restricted scale. A great city, as Aristotle said, is not a big city but one that does its work well. "Though I bestow all my goods to feed the poor," said St. Paul, "and though I give my body to be burned and have not charity, it profiteth me nothing." The charity of which the university is most in need is love for its spirit, devotion to its higher life, intelligent concern for the vital interests of its youthful members who come to us while they are still "wax to receive and marble to retain."

Without this, all else is of little worth. The contributions which the alumni are making to the material resources of the university will yield their full proceeds only if they shall be accompanied and sustained by contributions to its spiritual resources. Let the alumni think of themselves as still active members of the university, as students of a higher grade. The aim of education, we are told, is merely more education. Its test, we all believe, is to be found in capacity to make dis-

coveries, to discern new relations, to solve problems. It is a social adventure. There are departments of the university many of whose graduates remain in mutually fruitful intellectual contact with their former teachers. They continue to exchange ideas with one another. In an ideal university, once a student would mean always a student. Let us try to approximate to this ideal. An alumnus who continues to draw form the university inspiration and information and to put at its disposal the results of his own investigation and experience will be in a more favorable position to help his successors during their undergraduate days than one who has ceased to regard himself as a student, who is merely a regular subscriber or a casual visitor, reminiscent of the past.

If any alumnus earnestly desires to do something to encourage unusual excellence in scholarship among the undergraduates, but does not see just what he can do, we venture to suggest that he might possibly find it helpful to read, in the first place, John Erskine's essay on "The Moral Obligation to be Intelligent," for the sake of its well-sustained plea that what America needs is more knowledge; and in the second place, a little book entitled "Should Students Study?" by President W. T. Foster, of Reed College, for the sake especially of its well-balanced argument in support of the thesis that the students who do high-class work in school are generally those who do high-class work at college, and that those who do high-class work at college are generally those who do high-class work later in life.* Then let him read, if he has not yet read,

* President Foster shows for instance, on the evidence of statistics, that not one man in twenty years who was satisfied in Harvard College with grades of C and lower gained distinction in the studies of the Harvard Law School; that from the records of 1667 graduates of Wesleyan University, it is apparent that at that institution, of the highest-honor graduates (two or three in each class) one out of two will become distinguished, of Phi Beta Kappa men, one out of three, of the rest, one out of ten; that it is likely that the first quarter in scholarship of any school or college class will give to the world as many distinguished men as the other three quarters; and, in short, that the success of the undergraduate in his formal intellectual education is the safest single measure—

the chapters in "The Autobiography of Andrew D. White," which tell the story of the foundation and the early years of Cornell University, that he may become personally acquainted with the aspirations and the sacrifices that were built into its fabric. Let him get into touch, either in the course of a visit to the campus or by correspondence, with the present work and the present problems of one or more departments of the university. And then let him get hold of some student in whom he is interested and talk to him about it all and draw him out.

We lay stress upon this individual work because we believe that, in the long run, it is the kind that will count most. We suggest that the board of directors of the Alumni Association might well study its possibilities and take such action as may be feasible toward meeting more and more fully what we believe to be the desire of an increasing number of our alumni to keep in touch with the university and its work and to give time and attention to its necessities. A sustained effort might be made to promote such missionary activity on the part of earnest and well-informed alumni as we have suggested; and through the secretary of the Association Alumni and the secretary of the university the alumni organization might bring an increasing number of its members into personal contact with the university of to-day and of to-morrow and with successive generations of students.

Another opportunity for personal service on the part of alumni would, we believe, be afforded, if the several college faculties or any one of them should receive with favor the suggestion that orientation courses be provided for freshmen. An occasional address by an alumnus in such a course would stimulate interest and contribute useful information. Should orientation courses be instituted, we trust that the faculty committees in charge will desire and receive the coöperation of the alumni organization in arranging for talks by alumni.

though not the only measure—of the success he is likely to achieve in later life.

Even if no orientation courses should be instituted, there would still be room for such talks. No lectures given in the university have proved more useful and helpful than those in the course on citizenship, which was originally suggested and year after year has been arranged by a committee of alumni engaged in social service. Among the lecturers in this course have been a number of alumni, and they have given us, what speakers from the outside world can but do not always give, not pious generalities, but concrete information and specific lessons of experience. If the faculty should institute a convocation for the recognition of academic honors, we hope, as has been intimated above, that the speaker on that occasion would ordinarily be an alumnus of the university.

If, furthermore, the faculty should be of the opinion that the time has come to make a more definite appeal to the competitive instinct in the field of scholarship, there would be an opening for the establishment by individual alumni or by groups of alumni of prizes or of funded scholarships in each college. In some of the colleges such prizes might be awarded under conditions similar to those prescribed for the Boardman and the Fraser scholarships in the college of law. The Boardman scholarship is a prize of $100, awarded annually in June to the student who has, in the judgment of the faculty, done the best work in law subjects to the end of his junior year. There are two Fraser scholarships, of the value of $100 and $50, respectively, and these are awarded to seniors who have most fully evidenced high qualities of mind and character by superior achievement in scholarship and by those attributes of manliness which earn the commendation of teachers and fellow students. The award is made upon recommendation of the senior class by vote from a list of candidates submitted by the faculty as eligible by reason of superior scholarship. These prizes elicit keen competition. There is similar competition for the Fuertes medal, awarded annually to that student in the college of civil engineering who is found, at the time of graduation, to have maintained the highest scholarship in the courses of his college. Evidently we have in each

of these instances what Professor Willcox would call a social group in action. Such a group in the college of arts and sciences or in the college of agriculture would be found not in the senior or any other class but in those who are specializing in one subject or in a group of kindred subjects; and if prizes are to be given in those colleges, they should be put at the disposition of separate departments or groups of allied departments.

It is only fair for the committee to mention that Mr. Tatum, who first made to it the suggestion that alumni prizes for high scholarship might be established, coupled with this the proviso that, in awarding such prizes, consideration should be given not only to high class standing but also to success in other activities. It is also only fair to say that the committee has found general reluctance, among those who have given it their advice, to accept this proviso. The general opinion seems to be that sufficient recognition is already given to extra-curricular activities. In leaving the final decision to the candidates' fellow students, the rules governing the award of the Fraser Scholarships would appear to give an opening for sufficient recognition of qualities of mind and character which may not necessarily be revealed in the class-room.

The committee suggests to the board of directors of the Alumni Association that it may well consider the advisability of encouraging the establishment, under suitable conditions, of prizes for high scholarship, or even, as Mr. Sailor has suggested, of recommending the establishment of such prizes by the Associate Alumni.

The alumni might particularly consider the advisability of taking steps to increase the number of university undergraduate scholarships, offered each year to members of the incoming freshman class. There are now, under normal conditions, about 1,350 freshmen, and there are only eighteen of these scholarships. Each has an annual value of $200, but the recipients, except those from New York state registered in the state colleges, have to pay tuition, which now amounts to $150. There is keen competition for these scholarships and the suc-

cessful candidates are held rigidly to a very high standard of work. No honors conferred in the name of the university are more effective in promoting unusual excellence in scholarship.

The committee also suggests to the directors of the Alumni Association that further effort should be made to correct in the minds of our students the impression that the alumni as a body are concerned chiefly or exclusively with the athletic prestige of the university and that they reserve their approval for those students who have achieved success in athletics or in other extra-curricular activities. The action already taken by the alumni organization in initiating the inquiry to which this report is a response is itself evidence to the contrary and has already had its effect on undergraduate opinion. Nevertheless, it must be recognized that too many alumni lend support to the doctrine that it is "college life," rather than university work, which counts the most. As Mr. Newman says, a generation of alumni has gone out more or less inoculated with the idea that efficiency gained through "outside activities" is the best thing to be had from college life. "We are confronted," says the *Alumni News* (March 1, 1917), "by an undergraduate state of mind which most of us have helped, in the last thirty years, to create." To the more mature alumni in particular, and to all those who are unable to worship what has been called the Idol of Incidental Issues, the university must look for a sustained effort to revive the older and sounder traditions of Cornell, as a place where men's work counts for more than boy's play.

It must also be admitted that the boys' play is in many respects salutary and necessary. Professor Willcox points out that the lack of opportunities for social and competitive intellectual effort has led to the creation of student organizations in which the social desires for coöperation or team-work and competition or emulation can find expression. Among those men who win the C in athletics or who secure other prizes of undergraduate life there is a good proportion of high-grade students. They are often men of exceptional ability and ad-

mirable character, and the chief pity is that their desire and determination to excel have been diverted so largely into less important activities, that they have consequently lost much of the intellectual development which they were naturally qualified to attain, and that their prominence and popularity lead to a great depreciation of intellectual values. In general, we believe that the attitude of the undergraduates toward these things, if they are left to themselves, tends to become sane and sensible; but unfortunately the financial problems involved in the maintenance of a high standard of athletic achievement make it necessary to exaggerate its significance and particularly to resort to an extensive and intensive campaign of publicity which helps to drown out the claims of other and higher interests. If, by means of an athletic endowment, season tickets and gate receipts could be dispensed with, we believe that the evils of athletics would be largely if not entirely obviated; and there is no problem which deserves the attention of the alumni organization or of individual alumni more urgently than this.

Our athletes are, for the most part, modest and sensible fellows; but it would not be their fault if their heads were turned by the attention and the publicity which they sometimes receive. When, moreover, an influential group of Cornell alumni invites the representative schoolboys of its city and representatives of the alumni organizations of sister universities to turn out in honor of the captain of a champion football team, it is not surprising if some of those boys come to college with the idea that athletic distinction is the crown of an academic career. When two thousand Yale alumni, led by Mr. Taft, Mr. Depew, and Mr. Vance McCormick, assemble in honor of Yale's athletic heroes for the formation of a Varsity Club, to include all wearers of the Y, a Yale freshman may be pardoned for regarding that honor as more attractive than membership in Phi Beta Kappa. Within proper limitations all this has a natural justification, but it has gone too far. At their banquet this year the Cornell freshmen were told that if a Cornell man took more pride in his C than in

his diploma, it was because he might get his degree by boot-licking or bluffing, but he could not get a C that way. If there is any basis for this remark it is the fault of the faculty, but we believe the assumption to be unwarranted. It is true that candidates for athletic teams are advised to "get their lessons first," but no student will go very far who thinks that he is here to "get his lessons" rather than to take part in an age-long, organized campaign to advance the frontiers of science.

Again the committee would emphasize the importance of the influence exerted by individual alumni upon those undergraduates with whom they are acquainted, and again it suggests that an organized effort might be made to develop such individual influence.

One form of activity on the part of individual alumni or of alumni clubs which might well be promoted by the general alumni organization would be an effort to enlist for Cornell those boys and girls who at school have shown intellectual qualities which appear to warrant the expectation that they will make exceptionally good use of their opportunities at the university and that they will ultimately attain to positions of leadership in life. If it be true that there is a demonstrable and positive relationship between the valuation of ability at school and at the university, if it be true that the same relation exists between the promise given by undergraduates and their performance in professional schools, if it be true that the success of the undergraduate in his studies is the safest single measure of the success he is likely to achieve in later life, then the university will be heavily indebted to any alumnus who guides a gifted youth to his alma mater. Cornell does not need more men of merely athletic prowess or of merely social distinction but it needs all the time more men and women of ability, not only for the honor that they may bring the university in later life, but chiefly for the services that they may render while they are here in securing recognition for scholarship, in

quickening the whole body of undergraduates, in taking an active part in the coöperative advancement of knowledge. It must be recognized that the man, who, as an undergraduate, really "does the most for the university" is the man who helps it to do its work well.

Other and abundant opportunities for personal service are within the reach of all those alumni who are members of fraternities. A special responsibility rests upon the shoulders of fraternity alumni resident in Ithaca, but of the others there are many who come back frequently, and all are in a position to exert a continual and an intimate influence upon the corporate life of their younger brothers. So far as our experience and observation go, the undergraduate chapters appear to be reasonably willing to listen to the advice of their alumni. We must not demand too much; we must not expect gray heads to grow upon young shoulders; but we have a right to expect that every chapter here shall regard itself not as a boarding club but as a permanent social group, with traditions, with an outlook into the future, with a sense of its responsibilities as an integral part of an intellectual community. In every fraternity there are men who are endeavoring to live up to this high calling. Let the alumni in each fraternity back up such men; let them show their approval of a delegation which attains a good scholastic average, whether measured by marks or otherwise; let them encourage the active chapter to select among its initiates some men who give promise of the highest intellectual achievement and to bestow its approval upon those who fulfill such promise; let them encourage a man of ability and ambition to regard intellectual activity or possibly an academic career as an opportunity to serve his university and his country well. In too many fraternities freshmen and sophomores are virtually compelled to enter competitions of whose value they are not qualified to judge. In all fraternities there is a tendency to repress individuality, which can only be corrected by conscious and serious effort. There is a tendency to take more satisfaction in transient popularity and in "the

lightly proffered laurel of the campus'' than in the hard-won and less obvious rewards of moral and intellectual endeavor.

In one Cornell chapter of a national fraternity there is a scholarship key to be worn by that member who attains the highest scholastic standing. In another there are two annual prizes, one for that member whose marks are the highest, the other, of equal value, for the man who makes the most decided improvement over his record during the preceding term. Mr. Hoy tells us that he has just started two similar prizes in the fraternity of which he is a member and that he has had no trouble in getting more money from the chapter alumni than he needed for the purpose. Mr. Sailor suggests that a group of fraternity alumni might put up a scholarship trophy, to be held for a year by the chapter whose academic standing is the highest on the hill, and to become the permanent property of the chapter which wins it three or possibly five times. He also suggests that the alumni organization of any national fraternity might offer a prize to that chapter which, in any year, shows the most marked improvement in academic standing, as compared with other chapters of the same fraternity within a certain district. The committee is informed that the alumni of one Cornell chapter of a national fraternity have decided to provide a fund for two graduate fellowships to be filled each year by the best candidates from the fraternity at large, who will be expected to live in the house. We are also informed that many fraternities here have abandoned the literary exercises which, as is commonly believed, were once generally characteristic of chapter meetings. We suggest that fraternity alumni might promote a reconsideration of the value of such literary work and that, wherever it is resumed, annual prizes, possibly in the form of books, might be awarded to those members who have shown in such work the greatest originality or the greatest improvement. We also suggest that fraternity alumni should do their part to keep the chapter libraries well supplied with new and useful books, especially books relating to university life and education.

The committee suggests that the directors of the Alumni Association consider the advisability of holding an inter-fraternity alumni conference for the consideration of such questions as have just been indicated and of others that also require attention. It further suggests that at the general alumni reunion some such consideration be given to the serious problems by which the university is confronted as was contemplated for the first convention of Cornell Alumni. It ventures to hope that this report may suggest some topics the discussion of which by the alumni would throw further light on the problem which they have asked the faculty to consider.

Finally, we call attention to the concluding portion of a letter recently received by a member of the faculty, transmitted by him to this committee, and appended to this report. The letter was written by an alumnus of the class of 1915 and is published with his permission. He looks back upon his undergraduate days as a time of disappointment and disillusionment, due to the contrast between what he had expected and what he actually found at the university. He came up with a keen desire to know; but somehow no one seemed to care. He expected four years of intellectual companionship; but he found none. While some other men of similar interests and aims may have been more fortunate in finding congenial associations, we know that his experience was not unique, we believe that there are many who could make his words their own. They are less unfortunate, after all, than those who are not aware of what they are missing. It was for men of serious purpose that Cornell was founded; and we hope and believe that the time will come when they will again find here an intellectual atmosphere as keen and as congenial as in the early days of the university. In the course of time it has become a vastly larger, a less homogeneous, a more sophisticated community; we could not, if we would, revert to all its former simplicity; but, under new and complex conditions, we may, if we will, maintain what is best in our tradition. Under the new discipline of war, as the president of the university has

predicted, the whole country may become more sober-minded. Among the students who will come to us in the near future there may be many more who have learned to think seriously and to take their work seriously. We must make sure that such men are not disheartened but sustained by the spirit of the university. We must try to surround them with a social atmosphere favorable to the development of their gifts. We must make our appeal to the best aspirations of every one whom we admit to our fellowship. However large the number of our students may be, we must try to deal with them as individuals in a free community; for a university, as Cardinal Newman said, is an alma mater, knowing her children one by one, not a foundry, or a mint, or a treadmill. The war, which for the time being enforces a reduction in the size of the university and the suspension of many of its activities, may give us time, as it surely imposes upon us an obligation, to take thought and to prepare for the conditions which will confront us at its close. That there is work here for the alumni as well as for the faculty this report has attempted to indicate.

Respectfully submitted,

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HENRY S. JACOBY,
W. W. ROWLEE,
HENRY A. SILL.

June 1, 1917.

REINFORCED CONCRETE THEORY WITHOUT THE AID OF FORMULAS.

BY CHAS. A. ELLIS,

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CONCLUSION.

The design in matters pertaining to tensile and compressive stresses is within the limits of the specifications, and we are ready to take up the consideration of bond and shearing stresses.

Figures 5*b* and 5*c* represent respectively the variations of shear and bending moment. The two diagrams present several interesting features.

1. The horizontal unit of measure is one inch in both diagrams. The vertical unit of measure in the shear diagram is one pound, while the vertical unit of measure in the moment diagram is one inch-pound.

2. Since the beam carries a load of 58 pounds per inch, the shear line has a slope of 58 pounds to the inch.

3. The slope of the tangent to the moment curve at any ordinate shows the change-per-inch, or rate of change of the bending moment at that section of the beam, and equals the length of the corresponding ordinate in the shear diagram. Hence the rate of change-per-inch of the bending moment at any ordinate equals the shear at that ordinate. Thus at ordinate *A* the shear is 3,480 lb. and equals the rate of change (3,480 in.-lb. per in.) of the bending moment at the end of the beam. The moment curve is "steepest" and the rate of change of bending moment is greatest at the section of greatest shear. The bending moment increases less rapidly as the shear decreases and, ceasing to increase, becomes a maximum at *F*, where the shear ordinate is zero. The bending moment

(whether positive or negative) always reaches *a* maximum (not necessarily *the* maximum) wherever the shear curve passes through zero.

4. The difference in the lengths of any two ordinates in the moment diagram equals the area of the shear diagram between them. Thus in the moment diagram, the difference in lengths of the D and E ordinates is 1,769 in.-lb., which equals

$$\frac{1{,}798 + 1{,}740}{2} \text{ lb.} \times 1 \text{ in.},$$

the area in the shear diagram. The moment at the A ordinate is zero, hence

$$\frac{3{,}480 + 1{,}798}{2} \text{ lb.} \times 29 \text{ in.} = 76{,}531 \text{ in.-lb.},$$

the length of the D ordinate of the moment diagram. Finally the moment at F is

$$\frac{3{,}480 \text{ lb.} \times 60 \text{ in.}}{2} = 104{,}400 \text{ in.-lb.}$$

The amount of tension (T) or compression (C) at any section of this beam equals the bending moment divided by the effective depth (9.94 in.) and therefore varies as the bending moment. The diagram of Fig. 5*e* may be called a "tension-compression diagram" since each ordinate equals the length of the corresponding ordinate in the moment diagram divided by 9.94 inches. The vertical unit of measure in the moment diagram is one inch-pound. Each ordinate in the T or C diagram represents $\frac{\text{inch-pounds}}{9.94 \text{ inches}}$; hence the unit of measure is one pound.

The length of any ordinate in the diagram of Fig. 5*d* may be obtained by dividing the length of the corresponding ordinate of the shear diagram by 9.94 inches. Hence each ordinate in the diagram of Fig. 5*d* represents $\frac{\text{pounds}}{\text{inches}}$ or pounds-per-linear-inch.

The explanation of the fact that the rods at one section may have a tension, greater or less than the tension at another section, is the adhesive force or bond stress between the rods and the concrete.

Now the same relations must necessarily exist between Figs. 5*d* and 5*e* that hold between Figs. 5*b* and 5*c*. The slope of the tangent to the *T* or *C* curve at any ordinate shows the change-per-inch (rate of change) of the tension in the rods (or the compression in the concrete) for that section of the beam. This slope equals the length of the corresponding ordinate in Fig. 5*d*. Since any ordinate in Fig. 5*d* measures the rate of change-per-inch of the tension in the rods, it must measure also the intensity of the bond stress per linear inch. Therefore Fig. 5*d* may be called "the bond-stress-per-linear-inch diagram."

Consider the two sections of the beam at ordinates *D* and *E*. The tension in the rods is (Fig. 5*e*) 7,877.3 lb. at section *E*, and 7,699.3 lb. at section *D*, a difference of 178 lb. It is evident that the bond between the concrete and steel must account for this difference in tension.

The diagram in Fig. 5*d* shows that the bond stress per linear inch varies uniformly from 181 lb. at *D* to 175 lb. at *E* in a length of one inch. The average bond stress is

$$\frac{181+175}{2}=178 \text{ lb. per linear inch}$$

for this inch-length of beam.

The surface area of the three $\frac{1}{2}$-inch square bars in a length of one inch is 6 square inches. Hence the surface area per linear inch is $\frac{6 \text{ in.}^2}{1 \text{ in.}}=6$ inches. The bond stress per square inch of surface area or the bond unit-stress is obtained by dividing the bond stress per linear inch by the surface area of the three rods per linear inch (Fig. 5*f*). Hence the bond unit-stress at *E* is

$$\frac{175\frac{\text{lb.}}{\text{in.}}}{6 \text{ in.}} = 29.2\frac{\text{lb.}}{\text{in.}^2} \text{ or } 29.2 \text{ lb. per sq. in.;}$$

at D it is 30.2 lb. per sq. in.

The greatest bond unit-stress is required at A and is

$$\frac{350.1 \text{ lb. per lin. in.}}{6 \text{ sq. in. per lin. in.}} = 58.4 \text{ lb. per sq. in.}$$

The specifications allow 80 lb. per sq. in. The diagram in Fig. 5*f* shows the variation of bond unit-stress.

Shear.—By referring to a portion of the beam between any two vertical sections, as for example D and E (Fig. 5*a*), we note a shearing force on any horizontal section. The shear on the section *SS*, located at any* depth between the neutral plane and the rods, equals the difference in tension or the bond stress. Hence Fig. 5*d*, which represents the intensity of bond stress per linear inch, may represent also the intensity of horizontal shearing stress per linear inch, *on horizontal sections between the neutral plane and the rods.*

The horizontal shearing stress per square inch equals the horizontal shear per linear inch divided by 7 inches, the breadth of the beam. The diagram in Fig. 5*h* shows the variation of the horizontal shearing unit-stresses below the neutral plane for different vertical sections of the beam.

The horizontal shearing unit-stress is constant for all points in a given vertical section between the neutral plane and the rods, and equals

$$\frac{\text{shear at the section}}{\text{effective depth} \times \text{breadth of the beam}}.$$

The greatest horizontal shearing unit-stress is at A and is

$$\frac{3{,}480 \text{ lb.}}{9.94 \text{ in.} \times 7 \text{ in.}} = 50 \text{ lb. per sq. in.}$$

* This statement is based on the assumption that the concrete resists no horizontal tension due to bending moment.

Let us continue our discussion by referring to Fig. 6*a*, which represents the inch-length of beam adjacent to left support. The horizontal shear on a section just above the rods is 347.2 lb. As no tension is considered as acting in the concrete, there will be no change in this shear on any horizontal section below the neutral plane. Above the neutral plane the

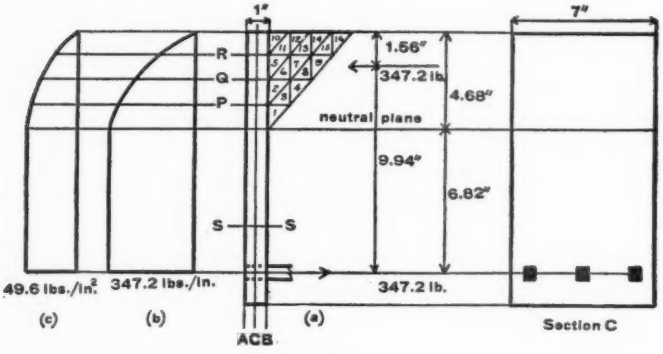

FIG. 6.

shear will decrease until it equals zero at the top surface. The decrease at any horizontal section is determined by the amount of compression represented by the triangular area below it. At section *P*, one fourth of the distance above the neutral plane, the shear is 347.2 $(1-\frac{1}{16})$ lb.; at *Q* the shear is 347.2 $(1-\frac{4}{16})$ lb.; at *R* it equals 347.2 $(1-\frac{9}{16})$ lb. The shear decreases as the square of the distance above the neutral plane. This decrease in shear, resulting from the integration of a triangle, is a parabolic variation, as represented in Fig. 6*b*. A similar relation exists between the triangular shear diagram and the parabolic moment diagram, Figs. 5*b* and 5*c*.

The horizontal shear on a section *SS* was found to be 347.2 pounds. The intensity of the horizontal shearing stress per linear inch is not constant across the section *SS* from *A* to *B*, but varies *uniformly* in accordance with the diagram in Fig.

5*d*. Hence Fig. 6*b* may be taken as the intensity of the horizontal shearing stress per linear inch at the section *C* midway between *A* and *B*. Fig. 6*c* is constructed by dividing the shear intensities of Fig. 6*b* by 7 inches, the breadth of the beam. Consequently Fig. 6*c* represents the horizontal shearing unit-stresses at the section *C*.

In accordance with a law of the mechanics of beams which states that the horizontal and vertical shearing unit-stresses at any point in a beam are equal, the diagram in Fig. 6*c* may represent also the vertical shearing unit-stresses on the section *C*. Let us see if the summation of the vertical shearing unit-stresses on the section *C* equals $3{,}480 - \frac{58}{2} = 3{,}451$ lb., the total external shear on the section. The area of the cross-section *C* below the neutral plane is 6.82 in. $\times$ 7 in., on which the vertical shearing unit-stress is constant and equals 49.6 lb. per sq. in. Above the neutral plane the vertical shearing unit-stresses have a parabolic variation from 49.6 lb. per sq. in. at the neutral plane to zero at the top surface; hence the parabolic area above the neutral plane (Fig. 6*c*) may be taken as the sum of the vertical shearing stresses on a vertical strip one inch wide of the cross-section above the neutral plane. The summation of the vertical shearing stresses on the section *C* may be made as follows:

$$49.6 \frac{\text{lb.}}{\text{in.}^2} \times 6.82 \text{ in.} \times 7 \text{ in.} = 2{,}368 \text{ lb.}$$

$$\tfrac{2}{3}(49.6 \frac{\text{lb.}}{\text{in.}^2} \times 4.68 \text{ in.})\ 7 \text{ in.} = 1{,}083 \text{ "}$$

Total vertical shear at section $C = 3{,}451$ "

Our purpose is to parallel the generalities of the formula method and not to attempt a discussion of any particular theory. The conventional method for the design of stirrups will be followed as outlined in the text-book.

The maximum shearing unit-stress is 50 lb. per sq. in. (Fig. 5*h*) which is greater than 40 and less than 120 lb. per sq. in. Hence the cross-section has sufficient area, but web reinforc-

ing is necessary for that portion of the beam where the shearing unit-stresses exceed 40 lb. per sq. in. The shearing unit-stresses increase uniformly from zero at the middle of the beam to 50 lb. per sq. in. at the end, hence $\frac{40}{50} \times 60$ in. $= 48$ inches $=$ distance from center of beam to the section where web reinforcement is necessary. Reinforcing is required along the 12 inches of the beam adjacent to the supports. U-shaped vertical stirrups will be used.

There should be sufficient surface on the vertical length of the stirrup below the neutral plane to develop a bond stress equal to the tension in the stirrup. Since the surface area varies with the diameter of the stirrup, while the cross-sectional area varies as the *square* of the diameter, it is evident that for a given beam there is an upper limit to the size of stirrup which may be used economically. Let us investigate a $\frac{3}{8}$-in. round stirrup, and assume that the lower seven inches of its vertical length are available for bond surface. The bond surface on one leg is

$$\tfrac{3}{8} \text{ in.} \times 3.1416 \times 7 \text{ in.} = 8.2 \text{ sq. in.}$$

At 80 lb. per sq. in., the bond stress which may be developed on the surface of one leg is

$$8.2 \text{ sq. in.} \times 80 \frac{\text{lb.}}{\text{in.}^2} = 656 \text{ lb.}$$

The cross-sectional area of a $\frac{3}{8}$-in. round bar is .1104 sq. in.; hence the tension which may be developed in one leg is

$$16{,}000 \frac{\text{lb.}}{\text{in.}^2} \times .1104 \text{ in.}^2 = 1{,}770 \text{ lb.}$$

A smaller diameter should be chosen; try a $\frac{1}{4}$-in. round bar.

$$\tfrac{1}{4} \times 3.1416 \times 7 \times 80 = 440 \text{ pounds} — \text{bond stress}$$

and

$$.0491 \times 16{,}000 = 785 \text{ pounds} — \text{tensile stress.}$$

While bond still seems to limit the amount of stress which the stirrup may be expected to carry, we will accept Hool's state-

ment that the rods may be considered secure against slipping if bent at their upper ends. One stirrup, therefore, is assumed to develop $2 \times 785 = 1{,}570$ lb.

The reinforcing is supposed to provide for two thirds of the vertical component of diagonal tension, the remaining one third being carried by the concrete. Since the diagonal tension is considered as acting at an angle of 45 degrees from the horizontal, its vertical and horizontal components are equal, and the spacing is usually measured by two-thirds of the horizontal shear per linear inch.

At the end of the beam the horizontal shear per linear inch is 350.1 lb. (Fig. 5*d*). Hence at the ends of the beam the theoretical spacing of the stirrups is

$$\frac{1{,}570}{2/3 \times 350.1} = 6.7 \text{ inches.}$$

. . . . . .

The discussion of a new topic should be introduced at the "psychological moment." The disastrous result which too frequently follows a non-conformity to this rule may be illustrated by a reference to the writer's personal experience in discussing the impact ratio $\frac{300}{(l + 300)}$, as given by the American Railway Engineering Specifications. The class had become reasonably proficient in the computations of live-load stresses, and the impact ratio was brought up in connection with a bridge 300 feet in length. The reader will understand how later developments convinced the writer that any other span length would have been more appropriate for the first application.

The writer believes that the question of average vertical shearing unit-stress should not be mentioned until the end of the treatment of rectangular beams and slabs, when the evaluation of the maximum shearing unit-stresses of 40 and 120 lb. per sq. inch in terms of their averages (35) and (105) will be less confusing.

T-Beams.—The illustrative problem on page 153 of the text-

book is chosen as a fair example for comparing the amount of work required by the two methods—formula and numerical.

Design a T-Beam with span of 40 ft. Assume dead load = 1,400 lb. per foot. Live load = 3,000 lb. per foot. The beam is to be simply supported at the ends, and the flange does not form a part of a floor system already determined. Use working stresses recommended by the Joint Committee.

The total bending moment,

$$M = 10{,}560{,}000 \text{ in.-lb.}$$

The maximum shear,

$$V = 88{,}000 \text{ lb.}$$

The required net web area,

$$b'd = \frac{88{,}000}{105} = 838 \text{ sq. in.}$$

To give ample space for the steel and still obtain satisfactory proportions for the cross-section, we shall select $b' = 18$ in. and $d = 47$ in. for a preliminary design. A thickness of flange of 12 in. will be tried.

FORMULA METHOD.

$$\frac{t}{d} = \frac{12}{47} = 0.256,$$

$$k = \frac{1}{1 + \frac{f_s}{nf_c}},$$

$$k = \frac{1}{1 + \frac{16{,}000}{15 \times 650}} = \frac{9{,}750}{25{,}750} = 0.378,$$

$$kd = 0.378 \times 47 = 17.8 \text{ in.},$$

$$z = \frac{3kd - 2t}{2kd - t} \times \frac{t}{3},$$

$$z = \frac{(3 \times 17.8) - (2 \times 12)}{(2 \times 17.8) - 12} \times \frac{12}{3} = \frac{53.4 - 24}{35.6 - 12} \times 4$$

$$= \frac{29.4}{23.6} \times 4 = 5 \text{ in.},$$

$$jd = d - z = 47 - 5 = 42 \text{ in.},$$

$$M_s = f_s a_s jd, \quad a_s = \frac{M_s}{f_s jd},$$

$$a_s = \frac{10{,}560{,}000}{16{,}000 \times 42} = 15.7 \text{ sq. in.},$$

$$M_c = f_c \left(1 - \frac{t}{2kd}\right) bt.jd,$$

$$b = \frac{M_c}{f_c \left(1 - \frac{t}{2kd}\right) t.jd},$$

$$b = \frac{10{,}560{,}000}{650 \left(1 - \frac{12}{2 \times 17.8}\right) 12 \times 42}$$

$$= \frac{10{,}560{,}000 \times 35.6}{650 \times 23.6 \times 12 \times 42} = 48 \text{ in.}$$

We shall use

5	1⅜-in. round rods	@ 1.485 =	7.4	sq. in.
7	1¼-in. " "	@ 1.227 =	8.6	" "
			16.0	" "

The 1⅜-in. rods will constitute the bottom row. Five 1¼-in. rods will be placed in the middle row with the two remaining rods above them. The three rows are spaced two inches apart.

The center of gravity of the group of rods is

$$\frac{(5 \times 1.23 \times 2) + (2 \times 1.23 \times 4)}{16} = 1.4 \text{ in. above the center}$$

line of the lowest row.

The bond for one $1\frac{3}{8}$-in. round rod is

$$u = \frac{V}{\Sigma ojd} = \frac{88{,}000}{4.3197 \times 42} = 485 \text{ lb. per sq. in.}$$

The number of rods which must extend to the end of the beam is

$$\frac{485}{1.5 \times 80} = 4.$$

Web reinforcement is unnecessary at a distance from support equal to

$$x_1 = \frac{l}{2} - \frac{v'b'jd}{w}\,*,$$

$$x_1 = \frac{40}{2} - \frac{40 \times 18 \times 42}{4{,}400} = 20\text{–}6.9 = 13.1 \text{ ft.},$$

$$BC = \frac{2}{3}\frac{Vb}{bjd} = \frac{2}{3}\frac{88{,}000}{42} = 1{,}395 \text{ lb. (Fig. 75 in text-book)},$$

$$r = 0.7AD = 0.7 \times 13.1 \times 12 = 110 \text{ inches.}$$

Hence, total stress to be taken by the rods is

$$\frac{BC}{2}r = \frac{1{,}395}{2} \times 110 = 76{,}700 \text{ lb.}$$

Six rods may be bent up, two at a time, in the following order:

$$x_2 = \text{or} < \frac{l}{2}\left[1 - \sqrt{\frac{m_2}{m}}\right],$$

$$x_2 = \text{or} < \frac{40}{2}\left[1 - \sqrt{\frac{2 \times 1.227}{16}}\right] = 12.18 \text{ ft.},$$

$$x_2 = \text{or} < \frac{40}{2}\left[1 - \sqrt{\frac{4 \times 1.227}{16}}\right] = 8.94 \text{ ft.},$$

$$x_2 = \text{or} < \frac{40}{2}\left[1 - \sqrt{\frac{6 \times 1.227}{16}}\right] = 6.44 \text{ ft.}$$

* This formula is found on page 95 of the text-book, except that b' is substituted for b. How many instructors find that the student makes this correction?

Numerical Method.

Refer to sketch in Fig. 7.

$$k:1-k::650:\frac{16{,}000}{15},$$

$$1{,}067k=650-650k,$$

$$k=\frac{650}{1{,}717}=0.378,$$

$$47k=0.378\times 47=17.8 \text{ in.},$$

$$f:650::5.8:17.8,$$

$$f=212 \text{ lb. per sq. in.}$$

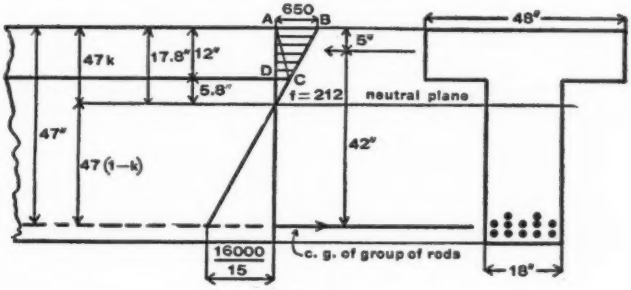

FIG. 7.

Moment of area *ABCD* about *AB*.

$212\times 6\times 8=$ 10,180

$650\times 6\times 4=$ 15,600

$862\times 6=5{,}172)\overline{25{,}780}$

5 in. from top surface to resultant compression.

47

5

Effective depth is 42 in.

$42)\overline{10{,}560{,}000}=$ moment

$16{,}000)\overline{251{,}400}=$ tension or compression.

15.7 sq. in. of steel required.

$5{,}172)\underline{251{,}400}$ = compression
48 in. = breadth of flange.

The center of gravity of the group of rods is

$5 \times 1.23 \times 2 = 12.3$*

$2 \times 1.23 \times 4 = \underline{\ 9.8}$
$16)\underline{22.1}$
1.4 in. above the center line of the lowest row.

$42)\underline{88{,}000}$ = shear at end of beam.

$120)\underline{2{,}100}$ lb. per lin. in., bond stress and maximum horizontal shearing stress at end of beam.

$4.3197)\underline{17.5}$ sq. in. per lin. in., bond surface required at end of beam.

4 rods must extend to end of beam.

$18)\underline{2{,}100}$ lb. per lin. in., maximum horizontal shearing stress at end of beam.

117 lb. per sq. in., horizontal shearing unit-stress at end of beam.

$\frac{40}{117} \times 20$ ft. $= \underline{\overset{20}{6.9}}$

at 13.1 feet from end of beam, the shearing stress has decreased to 40 lb. per sq. in.

Six rods *may* be bent up two at a time in the following order (Fig. 8):

* The average student entering upon his professional studies in the junior year frequently brings with him a few academic ideas which do not find favor in the eyes of the engineering instructor. An illustration is found in a comparison of the academic and professional arrangement of the computations for finding the center of gravity of the group of rods as set forth in the formula and numerical methods respectively. To the reader who has had a professional training as a draughtsman, checker or designer, comments are unnecessary.

$$\left(\frac{y_1}{2}\right)^2 : \left(\frac{40}{2}\right)^2 :: 2.454 \text{ sq. in.} : 16 \text{ sq. in.}$$

$$y_1 = 40\sqrt{\frac{2.454}{16}} = 15.64 \text{ ft.},$$

$$y_2 = 40\sqrt{\frac{4.908}{16}} = 22.12 \text{ ft.},$$

$$y_3 = 40\sqrt{\frac{7.362}{16}} = 27.12 \text{ ft.}$$

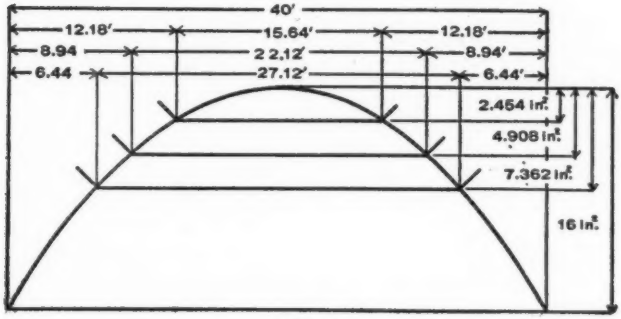

FIG. 8.

The writer believes that the graphical solution for locating the points at which the six rods *should* be bent up, may be somewhat simplified. The diagram in Fig. 9 corresponds in

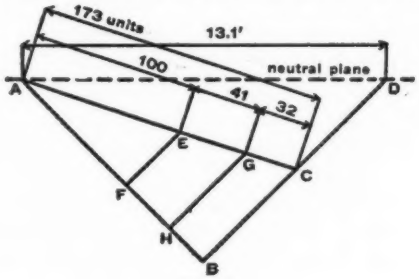

FIG. 9.

part to the author's diagram in Fig. 75, page 155. The areas of similar polygons are proportional to the squares of their homologous sides. If the triangle ACB is divided into three equal areas by the lines EF and GH, drawn parallel to BC, then

$$\text{area } \triangle AEF : \text{area } \triangle AGH : \text{area } \triangle ACB$$
$$:: \overline{AE}^2 : \overline{AG}^2 : \overline{AC}^2 :: \tfrac{1}{3} : \tfrac{2}{3} : \tfrac{3}{3},$$

$$AE : AG : AC :: \sqrt{\tfrac{1}{3}} : \sqrt{\tfrac{2}{3}} : \sqrt{\tfrac{3}{3}} :: 100 : 141 : 173.$$

or

$$AE : AG : AC :: 100 : 141 : 173.$$

The points E and G are easily located if the point C is chosen on the line BD so that AC will represent 173 units of measure to some convenient scale. If it were desired to divide the triangle into four, five or six equal areas, the point C should be chosen so that AC would scale 200, 224 or 245 units respectively.

. . . . . .

Introduction and climax, plot and dialogue are vital to the technic of a 50-minute recitation no less than to the structure of a short story. A recitation can be as interesting as a series of hairbreadth escapes or as prosaic as the "begats" of the Pentateuch. The instructor who stands in front of his desk and begins the first recitation of the course by asking John Smith how many barrels he thinks there would be in a mixture of one barrel of footballs, two of baseballs, and three of golf balls, has more than an even chance of enlisting sympathy and interest. The instructor who puts his knees under the mahogany, opens the book to page 7, and asks Smith to name the laws governing the theory of proportions—has missed his calling.

The average student experiences nothing very exciting in the derivation of a formula. It is true, perhaps, that the "plot thickens" with the procedure, but not in a manner which tends to stimulate his interest. Having studied a

lesson, let us say on bond stress, he has been able to derive the formula

$$u = \frac{V}{\Sigma ojd}$$

upon the blackboard to the entire satisfaction of his instructor, made a grade of 100 per cent and acquired some information, and that is all. The process is a Simon-pure exercise in memory work, and measures up reasonably well with the standard recently set by the college professor who remarks, "The instructor who goes into the class-room has two functions to perform; first, to impart information, and second, to maintain discipline." Possibly one function necessitates the other. Professor Swain seems to have a different view of the matter. He says: "Education is an opportunity, nothing more. It will not guarantee success or happiness or contentment or riches. Everything depends upon what development is produced by it and what use is made of it."* Development, that is a large word. Evidently we as teachers are employed to develop something, somehow, and somewhere. The first question is then: What are we supposed to develop?

Locke in 1690 said: "That which every gentleman (that takes any care of his education) desires for his son, besides the estate he leaves him, is contained (I suppose) in these four things, virtue, wisdom, breeding and learning. . . . You will wonder, perhaps, that I (being a bookish man) put learning last, especially if I tell you I think it the least part."†

It cannot be said that Locke's theory has waxed old and is ready to die. The demands of the engineering profession as set forth in Dr. Mann's report of the Joint Committee on Engineering Education seem to be in accord with Locke's idea. The profession is on record as claiming that *character, integrity, responsibility, resourcefulness* and *initiative* are 24 per cent of the engineer's total equipment; that *judgment, common sense, scientific attitude* and *perspective* represent 19.5

* "How to Study," by George F. Swain, McGraw-Hill Book Co.

† Essay: "Some Thoughts Concerning Education," § 134.

per cent; that *efficiency, thoroughness, accuracy* and *industry* represent 16.5 per cent; that *understanding of men* and *executive ability* represent 15 per cent; that *knowledge of fundamentals of engineering science* represents 15 per cent; and that *technique of practice and of business* represents 10 per cent. The words in this list seem to represent qualities, not things, nor facts, nor methods; and the development of these qualities should be our aim.

An attempt to re-classify each quality as a physical, mental or moral characteristic is an interesting exercise; but one fraught with perplexities and by no means conclusive, because of the very fact that physical, mental and moral attributes are not entities but functions each of the other. How can we doubt this fact when bad news affects our appetites and hunger tempts us to steal? Few of the characteristics, if any, are distinctly physical; while many are both mental and moral. Some of the qualities may be developed by study; others are the result of environment. Growth of character, like culture or refinement, comes from the influence of a personality as well as from the study of books. A non-technical elective may cause the student's intellectual horizon to recede and thereby give him breadth of view, but whether the student will gain culture and character is a question which concerns the personality of the instructor quite as much as the subject-matter of the course itself. Evidently we are to develop certain mental and moral qualities in the student, not only by precept but by example. How, then, shall we proceed?

The experiences of Smith and Jones are worthy of consideration. Smith decides to train for the two-mile run. He reports to the track coach, who gives him a two-mile ride over the course in a six-cylinder limousine, directs him to take a shower-bath and rub-down and to report at the same hour the next day. If this procedure is maintained indefinitely when will Smith become a bright and shining star in the athletic firmament?

Jones has other aspirations. He came to college "to get

an education." He registers in a certain course and spends three hours weekly in the lecture-room taking copious notes, listening, sleeping or perhaps reciting *words* which he has learned from his notes or text-book. On the third Friday of each month, by an "intensive review," he prepares for a written quiz on prescribed topics. At the end of the semester, by pumping all night, he sufficiently increases the pressure on his watered stock of knowledge to be able to flush a dozen pages during a formal and final examination which is conducted with great dignity; and gathers unto himself three semester-hours credit or the fractional part of a degree. But has Jones developed any of the specified qualities which will make for his success in engineering or in any other profession?

The experiences of the two men seem to differ materially in but one point. Smith's comedy is as imaginary as the value of the square root of minus one. The tragic experience of Jones is within the memory of many. Fresh air and cleanliness are essential for the athlete; but without strong lungs and agile limbs, he is beaten at the first barrier. Likewise memory exercise, although an important intellectual process, should not exclude imagination and reasoning. Which of these three plays the leading rôle in the drama of life is a question which is answered differently perhaps by the linguist, poet and scientist. It is a significant fact, however, that the majority of people who plead guilty to possessing a poor memory are much offended when accused of having little imagination or poor judgment.

We have in our midst physical training schools and manual training schools, fitting schools and finishing schools, reform schools and theological seminaries, technical schools and colleges, graduate schools and universities. But why do we never hear of *mental* training schools?

I believe that it was Professor Bird who said that he was not teaching chemistry, but rather employing chemistry as a means of teaching young men to think. Professor Swain remarks: "The student is not an empty vessel to be pumped

full of learning; he is a complex machine which education should help to run properly." It would be as difficult as interesting to ascertain how many educators have at one time or another subscribed to the statement: "We must make the student think," a mandate which frequently suggests the question: "How can you prevent his thinking?"

The student may interpret the instructor's request to think in several different ways. He will literally comply with the request if he memorize, imagine, reason or perform one of several other but minor intellectual functions. The intellectual development, however, varies with the form of exercise—a fact which the instructor should recognize and too often doesn't. There remains no doubt as to which intellectual function the student will *not* exercise when given a choice in the matter. Have you ever known students to memorize anything for the mere pleasure of it? On the contrary, when seen in pairs or groups and "on their own" they are more often than otherwise visualizing some future event in their lives or engaged in a heated argument. The subject of the argument may be trivial and the reasoning may not conform to the laws of logic, but that is not the point in question. They enjoy an argument: memory work is a task. How, then, does it happen that so many of them literally memorize their way through college? Perhaps it is because they are given little opportunity of doing anything else. Let us see.

I suppose that every college has its laboratory course which is caricatured by the student body as Physical-Training 13; or perhaps it is a lecture course known, *sub rosa*, as Morpheus 23. Such courses merit but a passing mention. But here is another course, let us say in the theory of reinforced concrete, conducted by a wide-awake, up-standing, thorough-going instructor. He assigns article 38 of our text for the next lesson, and tells the class that bond stress is a very important topic, which should be thoroughly mastered. How does Brown, who represents the average conscientious student, proceed with his lesson? As he reads the assignment, his attention is focused upon the derivation of the formula

$$u = \frac{V}{\Sigma ojd}.$$

Knowing the possibility of being called upon to derive the formula upon the blackboard, he follows the algebraic transformations very carefully to the end, memorizes the formula and says to himself, "I have got my lesson."

Brown has studied his lesson so thoroughly that on the following morning, as he walks to class, he can visualize and reproduce the lesson in his thoughts. But what does he *see*—the beam? I do not think so. The formula is his hero—and it finally becomes his master. He is gratified that he has a good text-book (in which I think we all concur) which makes everything clear and easy. During the recitation the formula is derived, explained, discussed and *ever thereafter used.*

Right here let us try an experiment. For two weeks or perhaps longer the class has been using the formula

$$k = \sqrt{2pn + (pn)^2} - pn,$$

which was derived in class *once* and has been used continually since that time. Suppose we ask the class point-blank to derive the formula for locating the neutral plane for reviewing the design of a rectangular beam. The results of such experiments are too frequently anything but gratifying.

Personally, I believe that Brown's experience is fairly representative. He has studied his lesson, exercised his memory, and gained some information. If anyone has exercised his imagination, it is the instructor, in thinking that Brown, in his study of article 38, has been exercising his reasoning faculties in the development of initiative, scientific attitude, and resourcefulness. The instructor who is frequently congratulated by his students upon his efficiency in "making things clear and easy" should at once take stock of his method and decide whether he is developing his students mentally, or simply feeding them information. The student is soon brought to the borderland of mental suicide if he is constantly given the opportunity of "learning a lesson" which contains

a new principle, *before* that principle has been thoroughly discussed in the class. The student himself should be required to develop the principle and arrive at the proper conclusions in class; and this end can be accomplished if the instructor is a master of the science and art of quizzing.

We will try to illustrate our idea of a quiz upon a topic for which no lesson has been assigned.

Instructor. A ten-penny wire nail is driven vertically a half-inch into the ceiling timber beam. Would you risk your weight upon it?

Student. I would not.

I. How does the term "penny" with a numeral prefix happen to be used to designate the different sizes of nails?

S. I don't know.

I. Please report on it at the next recitation. Would you risk your weight if the nail were driven an inch and a half into the beam?

S. I think so.

I. What determines the force necessary to withdraw the nail?

S. The friction or adhesion between the nail and the surrounding wood.

I. In a discussion of reinforced concrete the adhesion between the concrete and steel is called bond stress.

In the freshman-sophomore tug-of-war there were twenty sophomores and a mule* on one end of the rope. At two points on the rope, between which three men are pulling, the tension is 400 and 700 pounds respectively. Discuss the situation.

S. The three men are pulling an average of one hundred pounds each.

I. How does each man deliver the 100 pounds to the rope?

S. By the friction between his hands and the rope.

I. The friction or bond stress between the concrete and the horizontal steel rods in a beam is a function of what?

* The instructor who has no sense of humor is a misfit in the class-room.

S. It is a function of the tension in the rods.

I. The tension in the rod is a function of what?

S. It is a function of the bending moment.

I. If the bond stress is a function of the tension in the rods, and the tension in the rods is a function of the bending moment, what is your conclusion?

S. The bond stress is a function of the bending moment.

I. Where is the greatest bending moment in a simple beam, uniformly loaded?

S. At the middle of the span.

I. Where, then, is the greatest bond stress?

S. At the middle of the span.

I. At what point would the rods make the greatest effort to slip?

S. At the middle of the span.

The facial expressions of the class are an interesting study during the latter part of the quiz. An alert student who has been watching the instructor playing with the small deck of class cards which he has been bending into a cylindrical form, comes forward with the statement that the slip is greatest not at the middle of the span, but at the end, and "the fight is on."

The writer has never been able to agree with the opinion that the cause of a student's failure to pass in a course can always be traced to the instructor. He does agree, however, that it is usually the instructor's fault if a student is not interested in a course. The easiest and perhaps the best method of arousing interest is to provoke a verbal scrap among members of the class.

The instructor and the student whom he has been quizzing represent the "government," and the burden of proof is put upon "those of the opposition," who will eventually discover the fallacy in the argument; namely, that the bond stress is not a function of the tension per se, but of the *variation* in the tension, or variation in the bending moment, and the quiz continues.

I. Will you draw a picture illustrating your idea of the variation of bending moment?

The student sketches a simple beam uniformly loaded, draws the shear diagram, and directly below it the bending moment diagram.

I. What name is given to the curve in the bending moment diagram?

S. It is a parabola.*

I. What graphical relation exists between the two diagrams?

S. The ordinate or height at any point of the shear diagram measures the slope (of the tangent to the moment curve) or steepness of the moment curve at the corresponding point.

I. Where, then, is the greatest variation in height of the moment curve?

S. At the point of greatest shear.

I. Now make a summing up of the argument.

S. The bond stress is a function, *not* of the tension in the rods, but of the *variation* in the tension. The variation in tension is a function of the variation in the bending moment; and the variation of the bending moment is a function of the shear; therefore the bond stress is a function of the shear.

Of course, the answers as here given are not always forthcoming with the first attempt, frequently the instructor must attack the problem from a different angle; but always with the idea of getting upon common ground with the student by touching the latter's personal experience, thereby enabling the student to put side by side in his mind two ideas never before linked together in his thought. By such a method the student may develop mental power to cope with life's problems, the answers to which are not to be found between the covers of any text-book.

* If time permits, this answer is given some attention. See "The Structural Engineer's Parabola," *Journal of Western Society of Engineers*, April, 1917, p. 215.

UTILIZING INCENTIVE COMBINED WITH INTEREST IN TEACHING PRINCIPLES.

BY W. E. BULLOCK,

Assistant Secretary, American Society of Mechanical Engineers.

By those of us who were taught in the stoical school of fundamental principles, the modern movement toward vocational or occupational education is looked upon somewhat askance. We believe that attempts to teach vocations when commercial and industrial practice in those vocations advances so rapidly is not the ideal way from many points of view. We believe further, a two-years' try-out of a vocation in a classroom, though it may reveal the aptitude of the student, gives little indication of his ultimate propensities, since the experiment is a laboratory rather than an economic one. We believe, when all is said and done, very little is gained in departing from the stoicism of fundamental principles, upon which all practice and experience are based, and a knowledge of which opens up to the student not one, but a vast number of vocations.

On the other hand, we realize, with our vocational friends, that the stoical school of fundamental principles is not at all attractive to the average student in this industrial age. He has preformed a mind of his own which is realistic rather than fundamental, and which therefore sees little interest in studying the causes of things. With due respect to our vocational advocates, we suspect that this is one of the reasons for their being—the impatience of the student to learn application before principle, and the consequent impossibility of grinding the fundamental principles into his system so hard and so long that they become a part of his being.

Those of us whose business it is to impart knowledge should

bear in mind that not the least of the numerous factors upon which the degree of assimilation of the knowledge we wish to impart depends, are interest and incentive. A student will assimilate nothing which does not interest him, and he will assimilate more readily when he sees some incentive to learn and an educational method which combines both interest and incentive therefore offers double advantages.

Of the two factors, interest and incentive, the former is not hard to excite; it is the one great factor which vocational systems depend on to give the clue to the student's aptitude—his vocation is revealed as the task in which his interest is a maximum. The latter is an exceedingly intangible factor, and apparently on account of this very few educators employ the incentive method to any extent.

The purpose of this contribution is to suggest a practical and logical manner of developing the combined factors of interest and incentive in educational systems, with a view to accomplishing the highly desirable result of indelibly impressing upon students the fundamental principles of science and of giving them a mental equipment which will accrue to their advantage in the vocations.

The method utilizes as the primary incentive (it may be sacrilegous to say so before a professional organization) the ultimate turning of the knowledge of the principles to financial account. This is the strongest possible incentive that could be devised. It is the incentive which every student creates within himself, his only reason for wanting to learn, and its universality should therefore assure its recognition as a legitimate educational factor.

The method consists in nothing more nor less than teaching, in definite curriculum, the science of inventing, *per se,* truly a science, but one which probably as little educational effort has been expended to teach as any science, and which certainly has never been included in any school course.

By "the science of inventing" is meant the science of the application of the laws of nature, the properties of bodies, of

elements, or of substances to produce certain results or attain certain objects for the use and benefit of mankind. This is the science in which interest is universal and which, thanks to the patent systems in vogue in the various countries, incentive is of the strongest.

The fundamentals of the science of inventing itself are few —they can be set down in a paragraph. Every invention comprises four natural divisions or stages:

1. The principles or laws of nature, the natural phenomena, or the properties of substances or things employed in the invention.

2. The method of application of those principles—a process of manufacture.

3. The immediate result, the article which is manufactured, or the substance which is produced.

4. The ultimate result, that is, the object attained or the use to which 3 is put.

These fundamentals themselves are learned in a few minutes, but the applications of them may be extended and varied to embrace the thousands of useful inventions that have been made, and—here is the crux of the matter—the list of examples chosen for the study may be graduated and may be so extensive that all the fundamental "principles or laws of nature, natural phenomena, properties of substances or things" are included in them.

Progressive examples may be given from year to year, and the same fundamentals demonstrated again and again, and interest in the subject will never wane because incentive never decreases—the inventive faculty, one of the strongest educational motives, is being steadily developed. And, as already stated, fundamental scientific principles will become at the same time automatically absorbed.

What easier way to imbue a student's mind with the principles of gravitation and inertia than by exemplifying the invention of the pendulum, in which is involved (according to the fundamentals already enunciated)

(1) The principles of gravitation and inertia involved in the period of oscillation;
(2) The forms, mode of suspension and attachment;
(3) The complete article produced;
(4) The resultant property of the device in being capable of isochronous motion

or the invention of the explosive, involving

(1) The laws of ignition and combustion of certain elements;
(2) The process of mixing ingredients under safe conditions;
(3) The explosive produced;
(4) The force due to the sudden generation of gases at high temperature;

or the invention of the electric light, involving

(1) The laws of heating effects of the electric current;
(2) The choice of materials and the mode of combining and joining them;
(3) The lamp itself;
(4) The production of light by incandescence of part of the circuit in turning on the current.

The method, of course, is to apply similar analyses to the above in the cases of a multiplicity of inventions, and, later on, to supply examples given one or more fundamentals and required to find the remaining ones. Thus, reverting to the example of the pendulum, the student might be asked to devise other inventions for producing isochronous motion (balance wheel); or, in the example of a dye-stuff, to enunciate the principles involved, and to describe their mode of application in making the dye.

He should further still have it kept before him that new discoveries of fundamentals (2) and (3), that is, new processes or methods of production and new vendible articles are in all cases patentable.

In conclusion, it might be mentioned that this putting of the teaching of inventing on a positive basis could not fail to produce, besides the directly resulting benefit to the student described, an indirect benefit in the form of raising the art of

inventing to a higher plane. This indirect result is no mean one when it is considered that upwards of a million and a quarter "inventions" have been patented in this country in three quarters of a century, and that less than ten thousand of these are of real value. Inventors, as a class, are notoriously weak in scientific principles, and as a result much of their work is discredited by scientific men. Thousands of inventions, apparently practical, are upon analysis found to be based on incorrect knowledge of the laws of nature, natural phenomena, properties of substances or things.

The Franklin Institute of the State of Pennsylvania, one department of which has since 1824 annually reported upon inventions with a view of making awards, has so far found but 1,700 inventions worth reporting upon, or an average of 18 a year, though the number of patents granted each year runs into the hundreds of thousands! The Institute is trustee of a number of funds for making awards for meritorious inventions, but has, since 1824, only been able to make such awards in 400 cases, or at the rate of just over four a year, while the interest on one of the funds—the John Scott Legacy Medal and Premium, has accumulated to several thousands of dollars!

THE GRAPHICAL SIGNIFICANCE OF SOME ALGEBRAIC OPERATIONS.

BY ROY KEGERREIS,

New York City.

The concepts of most of the things in science to which mathematics is applied come to us through a picturing of curves, networks and geometric constructions. These graphs simulate the correspondence between the various factors and influences of the phenomena. Preparatory mathematical training will have less of a gap between it and the applied studies of science and engineering if a connection between the real and the abstract is constantly emphasized. Such methods are entirely similar to the application of analogies in the explanation of physical phenomena.

It seems as though we are too prone to operate with algebraic expressions per se, rather than at the same time to contemplate the beauties of our operations by viewing the corresponding scenes which are enacted on the coördinate plane. This matter is exceedingly important, since a majority of the "scientific steps" which we consider noteworthy are nothing more than a translation of a graphical concept to a mathematical one or vice versa. It is well known, for instance, that Faraday had a thorough and correct conception of the fields in the phenomena of electricity and it was only after reading his work that Maxwell set it into mathematical notation.

The power of manipulative ability in mathematics is a very desirable thing, which is possessed by few persons. However, it is generally the case that the "turning the crank" process will run much smoother if the student has a physical conception of what is being done, even though it may not necessarily always be viewed.

The retention of the various theorems will almost surely

be more permanent if some appropriate picture can be tagged on to each one for the student's mind's eye to visualize. The application of such a translation of algebra to certain theorems will be discussed with the view of emphasizing its utility in teaching a second course in algebra, especially to engineering students.

THEORY OF EQUATIONS.

Quadratic Equations.

All algebras consider the three cases of the solution of the quadratic equation.

I. Real and unequal roots.
II. Real and equal roots.
III. Imaginary roots.

$$y = x^2 - 5x + 6 \tag{1}$$

is an example of the first case. The roots are 2 and 3 and the equation may be written

$$y = (x-2)(x-3) \tag{2}$$

by definition or factoring. This may be expressed by

$$y = (y_1)(y_2), \tag{3}$$

where

$$y_1 = x - 2, \tag{4}$$

and

$$y_2 = x - 3. \tag{5}$$

The graphs of equations (4) and (5) are the parallel straight lines of Fig. 1. Equation (3) tells us that the ordinates of

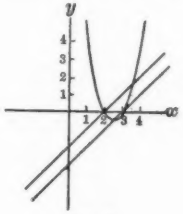

FIG. 1.

these two straight lines are to be multiplied together for each value of x. The curve which possesses these "product" ordinates is the graph of equation (1).

A parabola has been evolved from two straight lines, a thing which has a counterpart in calculus where it is shown that a parabola results if ordinates are made proportional to the integral of the right-angle triangular area between two intersecting lines. This is the case of real and equal roots (Fig. 2).

The above construction with the root factors shows the im-

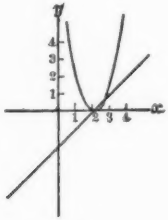

FIG. 2.

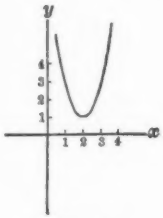

FIG. 3.

possibility of having real roots in the third case. That is, it is impossible to plot two lines so that the product of their respective ordinates will produce the curve of Fig. 3.

Higher Degree Equations.

A similar treatment of higher degree equations is also possible.

$$y = x^3 - 6x^2 + 11x - 6 \qquad (6)$$

is a typical equation of this kind and may be written in the form

$$y = (x-1)(x-2)(x-3). \qquad (7)$$

It is seen that there are three straight lines involved (Fig. 4). The products of their respective ordinates give the ordinates of the curve as shown.

It might be said that the graph of an equation, with all its roots real, consists of the "product" of as many straight lines of unit slope as there are roots. The intercept of the line with the x axis is determined by the sign and value of the corresponding root.

An entirely different graphical treatment for finding the

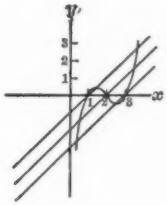

FIG. 4.

roots of a quadratic or cubic equation is described in some text-books. It consists of separating the equation in two parts (parabola and straight line) which are subtracted from each other. The abscissæ of the points of their intersection are the roots of the equation.

Descartes's Rule of Signs.

"An equation $f(x) = 0$ cannot have more real positive roots than there are variations in sign of $f(x)$ nor more real negative roots than there are variations in sign of $f(-x)$."

The rule is universally demonstrated on a purely analytic basis and the philosopher-mathematician who formulated it very probably did so in this manner. The graphical workings of the rule are brought out if the equation is considered as a collections of terms.

Take the equation

$$y = ax^3 + a_1x^2 + a_2x + a_3; \tag{8}$$

for simplicity let all the a's be unity, then

$$y = x^3 + x^2 + x + 1 \tag{9}$$

$$= y_1 + y_2 + y_3 + y_4, \tag{10}$$

where

$$y_1 = x^3 \quad \text{Cubical parabola,} \tag{11}$$

$$y_2 = x^2 \quad \text{Parabola,} \tag{12}$$

$$y_3 = x \quad \text{Straight line,} \tag{13}$$

$$y_4 = 1 \quad \text{Straight line.} \tag{14}$$

Fig. 5 results when these equations are plotted. The sum of the respective ordinates of these supplementary equations

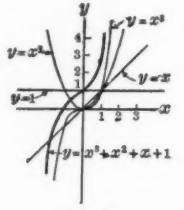

FIG. 5.

gives the corresponding ordinate of the graph of equation (9). It is evident that the graph of equation (8) cannot cross the positive x axis unless at least one term has a negative coefficient. The graph (Fig. 6) of

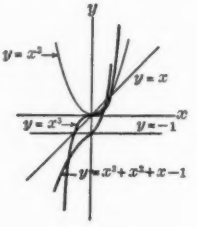

FIG. 6.

$$y = x^3 + x^2 + x - 1 \tag{15}$$

crosses the positive x axis once and has one positive real root. The graph may also cross the positive x axis once if the sign

of the highest powered term is negative. If one of the intermediate terms is negative the graph may cross the positive x axis twice. The fulfillment of the mays depends on the relative magnitude of the coefficients. Fig. 7 shows the condi-

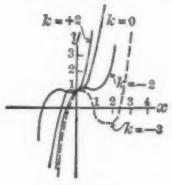

FIG. 7.

tions which prevail for different values of the coefficient of the term of second degree in a typical third-degree equation.

The graph of $f(-x)$ is an exact image, with respect to the y axis, of the graph of $f(x)$ since the odd-powered terms are reversed, accordingly it is the same thing all over again for the case of negative roots.

The Three Transformations.

I. *Diminishing the Roots by a Constant.*—The graph is shifted parallel to the x axis as is shown in most texts.

II. *Changing the Sign of the Roots.*—The graph is twice imaged, once with the x axis and once with the y axis. It is interesting to note that the two possible intervening images are merely the graphs of equations which are identical to the original and transformed equations except that one member is multiplied by minus one (Fig. 8).

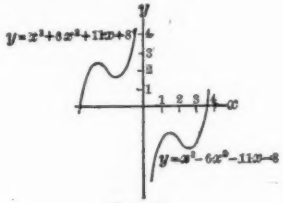

FIG. 8.

III. *Multiplying the Roots by a Constant.*—The graph is spread out in a rather complicated fashion.

Remainder Theorem.

$$f(x) = (Q(x))(x-a) + f(a). \tag{16}$$

The product in the right member is "multiplied" in the same manner as the factors of the quadratic and cubic equations were.

Consider for example the equation

$$y = x^3 - 6x^2 + 11x - 6 \tag{17}$$

$$= (x^2 - 2x + 3)(x-4) + 6 \tag{18}$$

$$= (y_1)(y_2) + y_3. \tag{19}$$

The vertical distance between the graphs of $f(x)$ and $(Q(x))(x-a)$ will obviously be the remainder since it is the difference between the dividend and the product of the quotient and divisor. When $x = a$ the product of $(Q(a))(x-a)$ will be zero (as is stated in the analytic proof), as Fig. 9

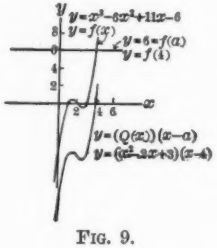

FIG. 9.

shows. The remainder can be nothing else but $f(a)$ since it will be the ordinate of $f(x)$ when $x = a$.

Partial Fractions.

Partial fractions are also amenable to a graphical demonstration.

$$y = \frac{4x-7}{x^2-5x+4} = \frac{1}{x-1} + \frac{3}{x-4}. \qquad (20)$$

Fig. 10 contains plots of the original expression and plots of the two partial fractions. Each partial fraction takes care

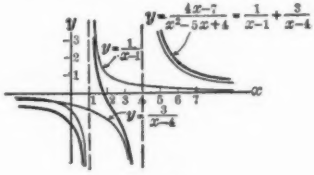

FIG. 10.

of one asymptote when the factors of the denominator are linear. Fig. 11 shows a case where one of the factors of the denominator is quadratic. Such a plot, besides showing that something is really connected up with the thing, is an excel-

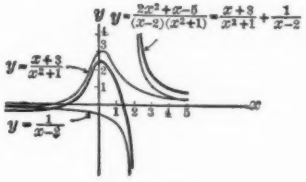

FIG. 11.

lent check on the work, since it is easy to note if the plots of the separate partial fractions add up to give the plot of the original expression. This check also insures that all the factors are prime, since if a quadratic term were factorable there would be two asymptotes "covered" by it.

Certain problems, after having been solved, can sometimes be more readily explained if recourse to a figure is had. An example of such a case follows; the explanation will be apparent (Fig. 12).

"A ship is twice as old as the boiler was when the ship was as old as the boiler is now. When the boiler is as old as the ship is now the sum of their ages will be 56 years. Find their present ages."

Solution:

Let $x =$ the present age of the boiler.

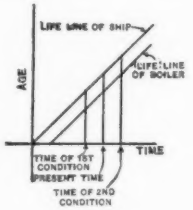

FIG. 12.

And $y =$ the present age of the ship.

Equation for the first condition:

$$y = 2(x - (y - x)), \tag{21}$$

$$3y = 4x. \tag{22}$$

Equation for the second condition:

$$(y + (y - x)) + y = 56, \tag{23}$$

$$3y - x = 56. \tag{24}$$

Substituting equation (22) in equation (24) gives

$$4x - x = 56,$$

$$3x = 56,$$

$$x = 18\tfrac{2}{3}.$$

Age of boiler $= 18\frac{2}{3}$ years.

Substituting this value in equation (22) gives

$$3y = 4(18\tfrac{2}{3}),$$

$$y = 28\tfrac{1}{3}.$$

Age of ship $= 28\frac{1}{3}$ years.

Complex numbers, determinants, progression, logarithms, empirical equations and the convergence of series have graphical significations which greatly aid students in getting an understanding of them. Geometric probability is also a much neglected thing which should be rejuvenated.

It is to be expressly noted that it is not intended to parade all these things as methods of solution. Their main purpose is to aid in explanation, *i. e.*, in giving the student a concept.

In actual engineering work data is taken and plotted. Perhaps a mathematical expression is manufactured to replace it and then the expression is manipulated according to the taste and ability of the engineer. Great assumptions are often made in order to have a workable expression. In many cases it is a question if something akin to the foregoing could not be directly applied to the original plot with improved results. It seems quite certain that less difficulty would be experienced in interpreting experimental results if students of science were trained to "feel" mathematical operations. This possibility and the fuller mathematical understanding given to the student seems to be ample justification for introducing such graphical work in algebra.

LOCAL SOCIETY MANAGEMENT DEMANDS MORE CONSIDERATION.*

BY C. E. DRAYER,

Secretary, Committee on Engineering, Coöperation, Cleveland.

MODERN STRUCTURAL PRINCIPLES OF GROUP ACTIVITY SHOULD GOVERN ORGANIZATION AND METHODS OF ENGINEERING SOCIETIES—CHOOSE OFFICERS WITH CARE.

At a time when the local engineering society is gaining so rapidly in recognition and influence but is still in the formative state it seems desirable to consider more fully than has yet been done some of the principles which should govern its organization and management. The subject is so broad that only a few features common to all local societies can be considered.

Often when a society is being organized much time is spent uselessly in framing a long constitution calculated to meet all future conditions. This presumes that the members of the society in the coming years will not be mentally equipped to care for situations confronting them. It indicates also an attempt to foresee the lines along which the future activities of the society is a mobile, flowing thing, serving its purpose best when allowed the greatest latitude to conform to the will of its members. The ideal constitution should embody organization structural principles only and provide for nothing except members, officers and money. Details should be left to by-laws, which should be few and easily amended to meet changing conditions. A long constitution tempts parliamentarily inclined members to epidemics of revision. No constitution can insure interest and loyalty, from which spring enthusiasm and initiative.

* Reprinted from *Engineering News-Record*, Vol. 80, No. 7, p. 301.

Broadly speaking, a society exists to do what the individual cannot do—develop its members to become successful both in the practice of their profession and in all their duties as citizens. This implies class consciousness. Other classes—doctors, lawyers and labor men—have demonstrated for years the value of acting in unison. Every engineer who has thought carefully on the subject has voiced the conclusion put in practice long ago by other classes, that unity is primarily within the province of the local society. State and national unity are merely larger measures of local unity.

Responsibility for the conduct of the society centers in the president and his immediate advisers, in whom the various lines of activity are harmonized. Careful provision should be made against choosing for officers men whose claim to the honor rests on distinction attained in the practice of the profession rather than wise and untiring leadership in the society. Equal care should be taken to guard against perfunctory, haphazard or clique choice. Probably the best way is to have a standing nominating committee whose business is to study constantly the growing timber in the membership and see that only those are put up for office who show true leadership, not mere persistence in work. Creative imagination, ability to interpret the heart, to say clearly what his fellows feel and to inspire loyalty, are necessary qualities for chief officers.

If a society has sufficient income to hire an executive secretary, a great deal of thought should be given to his selection, for on him perhaps more than on even the president rests the chance for success. The president usually changes each year, but the secretary may continue for many years. Prominent among the qualities desired in the secretary is vocational aptitude, which comprehends pleasing personality, ability to converse in a convincing manner and the power to stimulate the individual member to do his part. In no small measure the society will fulfill its mission if the individual member can be made active. An analsis of almost any society voluntary in character will reveal that its strength, its organized coöpera-

tion, is due to loyalty to some individual. Fortunate is the society that can pay this tribute to its secretary. Such a man has the incentive of his own success coupled with that of the society to become familiar with the laws of modern group activity, developed from the experience of successful organizations. He should be of the caliber to be trusted with authority not only in the business management of the society but to represent it in the absence of the chief officers in those delicate civic relations where even the right may lose if not tactfully presented.

Committees are divided into standing and special. The former have to do with the regular business of the society, such as property, finance, program and membership. The latter are created to care for special problems from time to time and exist until their work is completed.

A society member once facetiously remarked that he had been on a committee for two years but never found it had committed anything. A strong executive has been credited with defining an effective committee as composed of three men with one member out of town and one dead. Both remarks have been widely cited as a way of saying that it is an unusual committee that does continuous and effective work. The fault is not so much with the committee as with the kind of work expected of it, composed as it is of men who have numerous and important duties outside of the society.

It would be better to recognize a committee as mainly a deliberative and advisory body which must be provided with machinery to carry out its findings. This is usually done by the chairman or by a secretary provided for the purpose. The average civic-commercial body, such as a chamber of commerce, usually has sufficient funds to provide the necessary secretarial assistance—and herein lies the reason for the amount of work done by the committees of such bodies. If the younger engineer can be found with time at his disposal to act as committee secretary, it will take from the busy older men routine detail and afford the youngster a fine opportunity to gain experience

and make useful acquaintances. There is no more valuable asset for the engineer at the threshold of his career than a favorable acquaintance with the leaders of the profession.

Competent Chairman Gets Results.

The surest way to get a committee that produces is to place at its head a man who is competent and will work. The head of a great business recently said: "The secret of organization is to pass the buck to the right man and see that he does it." Courtesy has thus far prevented any president of a society from removing the chairman of a committee because he stagnates. Detail management takes time from the president already burdened with work. A suggested solution tried with success more than once is found in a steering or managing committee whose duty is implied in its name.

Of the standing committees none is more important than the program committee. Despite the usual limitation of funds, a strong program of diversified interest must be presented. What does the membership want and what does it need? We can discourse at length on the duty of each engineer to support a local society for the good of the profession and the good of the community, yet fall short if we fail to realize that the altruistic appeal is second to the selfish. The society must give service liberally to pay the average member for his outlay of time and money. Provision must be made to supply the papers on the latest theory, design and practice. The program committee or a similar one must provide the opportunity for the membership to gain the benefits that arise from personal contact and social intercourse. Smokers where the technical gives way to stories that melt the ice of diffidence must have a place. It must be recognized that the engineering society is in competition with other civic organizations. Hence the old style of society must give way to a program of action frequently recast and vitalized by innovation.

The most important membership asset of the society is the young man. It should be easy for him to find himself a mem-

ber even while an undergraduate. He should be trained assiduously in the way he should go in organization work. Inasmuch as he is anxious to prove himself in his life work, provision should be made for him to gain recognition for meritorious work in the society. Some societies provide a junior grade in which the charge to the young man is lower than the cost to carry him as a member.

Apply Test of Usefulness to Activities.

Among the early ambitions of all societies is the desire to obtain permanent quarters, establish a library and start a publication usually called the "Journal." The desire is to give the society a physical body, a material evidence of existence. Even the sacred institutions of library and publication should be compared unflinchingly for usefulness with other activities in which the society may engage. Unless there are funds for adding new books and for cataloguing in public library fashion to make the library a working tool, the society had better acknowledge that its boast of a library is empty and make arrangements with the local public library to make the books useful. Such arrangements have been made by two local societies. Reference work of the average member is more to articles in current technical magazines than to texts, hence nearly complete files of current technical magazines are a necessity. Bound periodicals dating back say five years and the latest and best books in the several engineering fields might well constitute the working library of the local society. One large local society maintaining perhaps the largest library of its kind in the country found that it could present to each member asking for a book an order for the purchase of the book and come out ahead financially at the end of the year.

The "Journal," as published by several societies, may be defined as a publication in which papers presented before the society are preserved in permanent form and is differentiated from the "Bulletin," published rather frequently and partaking more of the character of a news sheet. In a recent ob-

servation it was found that not more than 10 per cent. of the members examined the journal with care or read some of the articles. It would be an instructive experiment to place the journal on its own footing, making a budget to include voluntary subscriptions and other income, and charging against it all legitimate costs, including proportion of office expense and overhead. In suggesting such a study it is recognized that not every activity can be expected to pay its way. For instance, no one concerned in club management has been discovered by the writer who could make the dining room pay its way. Yet a club without dining facilities is hardly a club.

The Need of Cost System.

The above remarks directed to time-honored institutions of engineering societies implies that a cost system should be set up if the same efficiency in the use of money is to be approached as is reached by many members in their factories. Most societies make a budget, but none has said, for instance, how much it costs to collect dues and conduct the other activities that absorb a large part of the time of paid assistants. A successful manufacturer knows to the hundredth of a cent what his costs are, but an engineering society goes along blithely until the money is gone; then it raises dues or curtails necessary work. The annual incomes of several local societies pass the $10,000 mark. It would be well to have a standard system of cost accounting so that the results attained in one society could be compared with those of others.

SOURCES OF GOVERNMENT INFORMATION CONCERNING THE WAR.

Owing to the enormous increase of government war work, the governmental departments at Washington are being flooded with letters of inquiry on every conceivable subject concerning the war, and it has been found a physical impossibility for the clerks, though they number an army in themselves now, to give many of these letters proper attention and reply. There is published daily at Washington, under authority of and by direction of the President, a government newspaper—The Official U. S. Bulletin. This newspaper prints every day all the more important rulings, decisions, regulations, proclamations, orders, etc., as they are promulgated by the several departments, and the many special committees and agencies now in operation at the national capital. This official journal is posted daily in every postoffice in the United States, more than 56,000 in number, and may also be found on file at all libraries, boards of trade, and chambers of commerce, the offices of mayors, governors, and other federal officials. By consulting these files most questions will be found readily answered; there will be little necessity for letter writing; the unnecessary congestion of the mails will be appreciably relieved; the railroads will be called upon to move fewer correspondence sacks, and the mass of business that is piling up in the government departments will be eased considerably. Hundreds of clerks, now answering correspondence, will be enabled to give their time to essentially important war work, and a fundamentally patriotic service will have been performed by the public.

April 16, 1918.

EDITOR, BULLETIN OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA.

My dear Sir:

I am taking the liberty of sending you a brief notice regarding the Official U. S. Bulletin which I hope you may be able to use in the immediate future. Everything possible must be done at this time to relieve the governmental departments at Washington of the enormous amount of work imposed upon them since our entry into the world war. The notice I am sending you is self-explanatory, and I feel that much good will be done the government if this matter is given the widest publicity possible.

Please call on us if we can be of any service to you.

Very sincerely yours,

E. S. ROCHESTER,
Editor.

EDITORIALS.

Scholarship.—The editor was present at a meeting of college presidents a few months ago at which time an address was made by the president of a noted eastern university. He stated that as a result of the war courses, the faculty has discovered that students would study and work if they are interested. The tendency for engineering students to become so absorbed in their work that they neglect to give to the college social and athletic activities proper attention has been of long standing and during the last few years has been much discussed with beneficial results.

The war has taught many outside the above-mentioned university that a young man may be trained mentally without detriment to his social development while in college. Scholarship is not incompatible with breadth of view or a desire to take a normal part in college activities. In fact, the latter should be so regulated that sound scholarship is essential to participation in them. Anyone who has had the opportunity of becoming acquainted with the kind of men who are required to fill the responsible position in this war will appreciate the fact that sound scholarship is an essential prerequisite for their preparation in the war work.

The report of the special committee of the Cornell University faculty should be considered by every engineering school faculty.

The 1918 Meeting.—The twenty-sixth annual meeting comes when we are in the midst of a great war. Most of us have so many additional duties that it seems hardly possible that we can take time even to attend such a meeting to say nothing of taking part. However, the government has made extensive demands upon the engineering schools and they are meeting these demands in a way that is worthy of their past history.

Surely much benefit can be derived by the schools as well as by the members of the faculties if we gather for a few days for a discussion of the many problems which now confront us.

BOOK REVIEWS.

Infinitesimal Calculus. Section II. By F. S. CAREY, University of Liverpool. Longmans, Green and Co., New York. 1918. x + pages 145 to 352. $3.00.

The first section of this book appeared in 1917. This one contains Chapters XII to XX with Appendices I to VI inclusive. Some of the subjects treated in an interesting manner are tangential polar equations, intrinsic equations, point-roulettes, line-roulettes, the general motion of a lamina in its plane, nomograms, the hexagonal abacus, and the parallel abacus. There is a chapter on differential equations, and answers to the numerous problems are given at the end of the book.

F. A. F.

Elements of Machine Design. By O. A. LEUTWILER, M.E. McGraw-Hill Book Co., Inc., 1917. 6½ × 9¼. 607 pages. $4.00.

The author has presented the elements of machine design compiled in a very thorough and up-to-date manner. The work contains the principles, facts, formulas and data necessary in the modern theory and practice of machine design. All subjects under discussion are well illustrated with drawings of modern machine parts.

The book is a very good text for the student and a valuable reference for the engineer or designer.

W. W. B.

Fundamentals of Illumination Design. Issued by the ENGINEERING DEPARTMENT, NATIONAL LAMP WORKS, Nela Park, Cleveland, O.

This bulletin is an excellent one for the practical man. The

entire pamphlet, consisting of sixty-five pages, is expressed in a simple and apprehensive manner. It is written in popular language, higher mathematics and advanced science is entirely omitted. It is adapted to the requirements of those engineering students who should acquire a brief knowledge of interior lighting but have not the time to spend taking a complete course in illuminating engineering. The book is probably the best of its kind and size. This booklet is divided into four parts, dealing with the following phases of illumination: photometric units and distribution curves; reflectors, shades and glassware; principles of interior illumination design; and solutions of practical problems.

J. E. K.

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The Bulletin is the official organ of the Society. It is published monthly from September to June. It contains not only the text of papers presented before the Society, but also college notes, short contributions from members, and matters of general interest to all persons connected directly or indirectly with technical education.

The Society comprises about fifteen hundred teachers, engineers and other persons interested in technical education and a considerable number of educational institutions.

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